

HEAD ASSEMBLY FOR A CUTTING MACHINE

CROSS REFERENCE TO RELATED APPLICATION

This is a divisional of United States Application No. 09/541,000, filed March 31, 2000 and now issued as United States Patent No. \_\_\_\_\_, which was in turn a divisional of United States Application No. 09/151,179 filed September 10, 1998, and now issued as United States Patent No. 6,178,860. The entire specification of the aforesaid applications and patents are hereby incorporated hereunto by reference thereto.

BACKGROUND OF THE INVENTION

Automated systems for cutting mat board and the like, which operate under computer control (CNC matcutters), are known in the art and are commercially available. (See for example the article entitled "Computerized Automated Matcutters" by Robert Palmer, *PFM Magazine*, May 1995, pages 66-86.) The cutting head employed in such apparatus typically has an associated glide plate that surrounds the tip of the blade, which facilitates movement over the board and improves cutting.

A difficulty that arises due to the presence of such a glide plate concerns interference with elements used for clamping the workpiece in place against the machine table. The clamping elements not only limit the closeness of approach of the blade to the edge of the board, and consequently border width, but they also preclude sizing (i.e., cutting of a smaller piece of mat board from a larger one) because the blade cannot move all the way to the edge of the workpiece.

Other deficiencies that are typically present in matcutters of the prior art concern operation of the head itself. For example, the motion of the head components by which blade plunging is effected is often not sufficiently smooth and well-controlled to enable the production of optimal cuts, and the construction often does not afford facile and precise relative positioning of the parts comprising the head.

# SUMMARY OF THE INVENTION

Accordingly, it is a broad object of the present invention to provide a novel cutting head assembly suitable for use in a matcutter, and especially a computerized automated matcutter, wherein operation of the components is smooth and well controlled, and wherein the construction affords facile and precise relative positioning and repositioning.

It has now been found that the forgoing and related objects of the invention are readily attained by the provision of a head assembly for a mat cutting machine, comprising a head having mounting-means for movement of the assembly on an axis, and defining a first channel oriented at an oblique angle to the axis; a slide mounted for slidable movement in the head channel, between a withdrawn blade position and a plunged blade position, the slide having a second channel therein extending substantially parallel to the first channel for receiving a blade-holding magazine inserted thereinto; and such a magazine dimensioned and configured for slidable insertion into the second channel of the slide. The slide and head have first cooperating mechanical means thereon for adjustably limiting the movement of the slide to the plunged blade position, and the slide and magazine have second cooperating mechanical means thereon for adjustably limiting the depth of magazine insertion in the second channel.

The head assembly will preferably include a linear motion support system for the slide, which support system comprises, on each of two opposite sides of the slide, an array of at least three elongate rectilinear elements mutually spaced to define a passage therewithin, and a multiplicity of bearing elements loosely stacked within the defined passage. The slide may advantageously have a boss defining a threaded aperture that opens to the second channel, with a tightening screw received within the aperture for clampingly engaging a cutting blade received in the magazine. Most desirably, the assembly will comprise at least a second magazine, with a locating component of the second cooperating means on the first-mentioned magazine being disposed differently from the corresponding locating component

on the second magazine, and with the slide having separate abutment components for independently engaging each of the locating components of the first and second magazines.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5        Figure 1 is a perspective view of a computerized automatic matcutter in which the head assembly of the present invention is suitably employed;

10        Figure 2 is a fragmentary perspective view, drawn to an enlarged scale, showing a section of the cutter of Figure 1 including the cutting head assembly and its mounting track, and the mat-supporting table;

15        Figure 3 is a sectional view, taken along line 3-3 of Figure 2 and depicting one of the clamping units in greater detail, drawn to a further enlarged scale;

20        Figure 4 is an exploded elevational view, in partial section, showing the clamping unit of Figure 3;

25        Figures 5 and 6 are fragmentary sectional views, drawn to a further enlarged scale, showing the button of the clamping unit in its lowered and elevated positions, respectively;

30        Figure 7 is a fragmentary elevational view, in partial section, showing the cutting head assembly and operating mechanism, and an underlying section of the table and workpiece;

35        Figure 8 is a fragmentary perspective view of the cutting head assembly, with the blade magazine thereof shown in exploded relationship;

      Figure 9 is a bottom view of the cutting head assembly;

      Figures 10, 11, and 12 are fragmentary sectional views, taken generally along line 9-9 of Figure 9, showing raised (Figure 10) and lowered (Figures 11 and 12) positions of the cutting head assembly, and withdrawn (Figures 10 and 11) and plunged (Figure 12) positions of the blade-mounting slide;

      Figure 13 is an exploded perspective view showing the components of the blade magazine;

      Figure 14 is a perspective view showing the magazine components in assembled relationship;

Figure 15 is a fragmentary elevational view of the cutting head assembly with a portion broken away to expose the elements by which the magazine-mounting carrier slide is supported;

Figure 16 is an exploded perspective view showing components of the slide-mounting arrangement;

Figure 17 is a fragmentary view of the cutting head assembly, with a portion broken away to show the magazine-mounting slide and its supporting elements;

Figures 18, 19, and 20 illustrate three different blade magazine assemblies which may alternatively be employed in the cutting head assembly of the apparatus;

Figure 21 is a fragmentary rear view of the table of the matcutter, showing the pneumatic system and control box for operating the clamping units and the cutting head assembly; and

Figure 22 is a diagram showing the pneumatic control panel assembly of the apparatus.

#### DETAILED DESCRIPTION OF THE PREFERRED AND ILLUSTRATED EMBODIMENTS

Turning now in detail Figure 1 of the drawings, therein illustrated is a computer-operated matcutter embodying the present invention, including a vertical unit for supporting the workpiece and the cutting head and associated mechanisms. More particularly, the vertical support unit includes a rectangular frame, generally designated by the numeral 10, within which is mounted a rectangular table 12. Top and bottom rails 14, 16, respectively, provide horizontal "X" direction gantry tracks, by which a "Y" direction gantry track 22 is slidably supported at its opposite ends. A stepper motor 18 is disposed at one end of bottom rail 16, and is fitted with a pinion for driving an endless timing belt (not seen) in a continuous circuit along the bottom of the frame; a similar timing belt is provided along the top of the frame, and is driven by the motor 18 through a suitable connecting shaft 20, the timing belts serving to effect movement, in the X direction, of the Y gantry 22. A second stepper motor 24 is disposed at the upper end of the gantry 22, and drives another timing belt 28 in a continuous circuit along the gantry

22, suitable reversing units being provided, as at 30. A control cabinet 32 is supported at one end of the frame 10, and contains computer components and control elements for operation of the cutter, and an operator's terminal 34 is provided adjacent the unit. The computer software displays icons which show directly, for selection, the numerous shapes that can be cut; it also prompts the entry of dimensional parameters, cutting mode choices, etc. A cut workpiece W is clamped upon the surface of the table 12; a large workpiece W' and a smaller workpiece W" (both shown in phantom line) illustrate pieces of mat board from which the workpiece W may be cut, in sizing operations, utilizing the cutter of the invention.

With particular reference now to Figures 2 through 6 of the drawings, the clamping units that are used to hold the workpiece in position against the surface of the supporting table 12 are shown in detail. The table 12 consists essentially of a base 36 (e.g., of wood), over which will normally be positioned a slip sheet 38. A cylinder bracket, consisting of an outer collar portion 40, an inner mounting portion 42, and an interposed annular flange 44, is mounted with the outer collar portion 40 extending through a circular hole 41 formed in the base 36. A double-acting pneumatic cylinder, generally designated by the numeral 46, has a threaded stub 48 on one end which is engaged within the inner collar portion 42, the latter being matingly threaded at 43 for that purpose. The threaded end portion 50 of a piston (not seen) extends through the passage 52 of the cylinder bracket and serves to mount a clamping button, generally designated by the numeral 54, the button having a threaded recess 56 in its cylindrical body portion 58 for engagement of the shaft end portion 50.

The head portion of the clamping button 54 comprises an annular lip 60, which is circumferentially undercut to define an inwardly tapered shoulder 62; the screwdriver slot 66 in the top of the button may be used to facilitate attachment and removal. As best seen in Figure 5, the workpiece W is engaged under the lip 60 of the button 54 in its retracted position, with the taper of the shoulder promoting penetration into the surface

of the workpiece and thereby enhancing the grip thereupon. It is to be noted that the surface 64 of the head portion of the button 54 lies flush with (or slightly below) the upper surface S of the workpiece W in the clamping position. Because of that relationship the glide pad 68 (shown in phantom line in Figure 5) can pass without impediment from the surface S of the workpiece over the surface 64 of the clamping button 54, which feature constitutes a primary benefit of the invention disclosed. It will also be noted from Figure 1 (as well as from Figure 21) that a multiplicity of clamping units are arranged along both the X axis and also the Y axis of the table 12. Although spacing is not critical, the particular arrangement shown in Figure 1 is beneficially designed to provide optimal clamping for a wide range conventional sizes in which mat board is provided and to which it is to be cut.

Attached to the bottom of the double-acting pneumatic cylinder 46 is a Tee connection 70, and a like Tee connection 72 is attached near the top. Air injected into the bottom cylinder through line 74 (from a source to be described) elevates the piston of the cylinder and, in turn, raises the clamping button 54 to its release position of Figure 6; conversely, pressurized air delivered through line 76 to the upper Tee connection 72 will (with release of the pressure at the bottom of the cylinder) drive the button 54 downwardly and maintain it in the clamping position shown in Figure 5. Lines 78 and 80 lead from the Tee connections 70 and 72 for the supply of pressurized air to downstream cylinders, which are connected in series.

As mentioned above, a very significant disadvantage that is inherent in clamping systems of the prior art is attributable to the interference that clamping elements employed present to movement of the glide pad that is conventionally associated with the cutting head. Because the clamping buttons 54 of the units employed in the present cutter lie flush with the surface of the mat clamped board (or substantially so), the pad can readily pass thereover, enabling the blade to move fully to the edge of the workpiece. In those instances in which the cutting blade is in such position that it would itself encounter a clamping

button, computer control can be utilized to shift the entire cutting pattern as necessary to cause the blade to bypass the button, in a manner analogous to a standard "trimming" operation. Alternatively, it is possible to mount the clamping units so they are themselves movable out of the path of the blade, e.g., on a mounting strip that is embedded in or affixed to the support table.

Figure 2 shows the cutting head assembly 26, mounted upon a carrier generally designated by the numeral 84, which is in turn slidably engaged on the Y gantry 22 for translation therealong, as driven by the motor 24 and associated timing belt 28. Precise movement of the carrier 84 along the gantry 22, and of the gantry 22 along the X gantries 14 and 16, is achieved in accordance with principles and mechanisms that are well known in the art of computerized automated cutters for mat board and other materials.

As is best seen in Figure 7, the cutting head assembly 26 includes a head sleeve 86, which coaxially receives a center shaft 88 which is in turn coupled to the double-acting piston (not visible) of a pneumatic cylinder 90. A circumferential shoulder (also not visible) extends about the bore of the head sleeve 86 and engages elements on the center shaft 88 in its downward travel, to move conjointly therewith. A spur gear and collar unit 92 is clamped to the sleeve 86, the gear portion of which is in meshing engagement with the pinion gear 94 of a stepper motor 96. The motor 96 is mounted upon a slidably supported plate 97, to which a lateral bias is applied by coil spring 99, which bears upon the adjacent wall 101 of the cutting head assembly housing; this arrangement serves to keep the pinion gear 94 in uniform meshing engagement with the spur gear 92, thereby avoiding backlash and minimizing motor noise. Coil spring 98 surrounds a nylon sleeve 87, mounted on the head sleeve 86, and applies a downward bias to the cutting head assembly 26. The double-acting cylinder 90 has coupling elements 91, 93 for connection to a pneumatic system (to be described) in such manner that pressure can be applied to either side of the operating

piston so as to positively effect raising and lowering of the head assembly 26.

As will be apparent, the head assembly is rotated (through a 360° angle) by the motor 96, acting through the spur and pinion gears 92, 94. The frame 100 of the head assembly includes a block portion 104 in which a permanent magnet 102 is mounted. The magnet 102 cooperates with a sensor 103 to generate a signal that indicates when the magnet and sensor are in alignment, and hence when the cutter assembly 26 in its home position; the angular position of the head assembly, as rotated by the motor 96, is thereby precisely controlled (through computer software).

The frame 100 of the head assembly 26 obliquely mounts a slide assembly, generally designated by the numeral 108, which in turn carries a blade magazine assembly, generally designated by the numeral 110; the magazine assembly includes a Dexter No. 3 style cutting blade 112. The slide assembly 108 includes a body 114, into which is machined a U-shaped channel 118 that extends along its length and in which the magazine assembly 110 is seated. A groove 120 is formed in each of the two lateral edges of the body 114, and extends lengthwise thereof, parallel to the channel 118; the groove 120 on one side of the body 114 is best seen in Figure 17, the body 114 being symmetric about the longitudinal centerline of the channel 118.

The frame 100 of the head assembly 26 is formed with an oblique channel 127 in which the slide assembly 108 is seated. A lateral slot 122 extends along each side of the channel 127 in registry with the grooves 120 along the opposite sides of the slide body 114; again, only one of the head slots 122 is illustrated, and is best seen in Figure 17. A pair of dowel pins 124 extend longitudinally along each of the body slots 120, and a cooperating pair extend longitudinally in the head slots 122. A column of spherical ball bearings 126 (13 bearings being employed in the illustrated embodiment) are loosely disposed in the space between each set of dowel pins 124 (two cooperating pairs), to provide a frictionless linear mounting for the slide 108 within the head frame 100. An L-shaped steel rail 128 is seated within each slot 122 of the head, and includes a lower



leg portion 129 to provide underlying support for the column of ball bearings 126. A pair of set screws 130 extend through the head frame 100 into communication with the slot 122, and bear upon the longer leg of the rail 128; the set screws 130 enable an adjustable force to be applied to the dowel pins 124 and bearings 126, with any force applied being effectively balanced between the opposite sides of the slide assembly 108. A cover plate 131 is held in place on a shoulder portion of the frame 100 by screws 132, and serves to prevent escape of the ball bearings 126 from the upper ends of the slots 120, 122. It might be pointed out that the travel distance of the slide 108 is sufficiently limited that the bearings 126 make no more than a single revolution during movement of the slide from its most outward to its most inward position, thereby minimizing adverse scuffing effects; it is unnecessary to separately retain the bearings 126, as within a cage or the like.

As is best seen in Figure 13 and 14, the blade-holding magazine of the assembly 110 consists of an elongate body portion 134 which is longitudinally slotted at 136 to receive the blade 112. A magazine head portion 133 is transversely slotted at 142, and has formed therethrough an axially extending threaded aperture 144 in which the screw 146 is engaged. The screw 146 passes through an O-ring 138 seated in the slot 142, and bears against the end of the blade 112 to secure it in position against the oblique shoulder 148 that defines the outer end of the slot 136. A locating pin 150 projects rearwardly from the magazine head portion 130.

The locations of the oblique shoulders 148 and the locating pins 150 distinguish the three magazine assemblies depicted in Figures 18 through 20 from one another. As can be seen in Figure 18, the pin 150A is on the left side of the magazine assembly 110A (as viewed from the front); in the magazine assembly 110 shown in Figure 19 (and Figures 13 and 14), the pin 150 is on the right, and the shoulder 148 is spaced somewhat further from the leading end of the body 134 than is the shoulder 148A; the pin 150B in the magazine assembly 110B of Figure 20 is on the left and the shoulder 148B is spaced slightly closer to the

leading end of the body 134B than is the shoulder 148A. The magazine assembly 110A is adapted for use for standard cutting operations; magazine assembly 110 is adapted for V-grooving, because the blade must make a shallower cut so as to avoid penetrating entirely through the mat; magazine assembly 110B is adapted for deep cutting, such as to penetrate multiple plies of mat board. The O-rings 138, 138A and 138B of the respective magazines assemblies are color-coded so as to enable facile selection by the operator. It will be appreciated that, although the magazine assembly described herein includes certain features that are similar to those of the magazine described in Kozyrski et al. U.S. patent No. 4,867,023, the instant assembly is unique and particularly well-adapted for the purposes for which it is intended.

Consistent with the described functions, the pins 150, 150A and 150B are positioned to register with one or the other of the two locating screws 152, 152' engaged in the slide assembly cover 116 and projecting upwardly therefrom. The pins 150A and 150B will engage the head of the screw 152 when fully inserted, and the pin 150 will engage the head of the screw 152'. Needless to say, the screws 152, 152' are adjustable so as to enable close control of the extend of projection of the tip of the blade 112.

A pair of ears 153 project upwardly and forwardly from the slide body 114, and mount a short rod 154 therebetween on which is in turn supported a roller 156, the function of which will be described presently. A threaded aperture 158 extends longitudinally at the base of the ears 153, and receives a set screw 160 which is positioned to engage a crossbar 161, which extends between portions of the head frame 100 and serves to limit downward travel of the slide assembly within the head channel 127.

A collar 162 projects normally to the plane of the slide body 114, and has a threaded aperture 164 therethrough in which is engaged a clamping screw 166. Tightening of the screw 166 against the blade 112 serves to secure it and the magazine assembly 110 in fixed position with the slide assembly 108.

The center shaft 88 extends axially through the head frame 100 and the head sleeve 86. It is operatively connected to the

piston within the cylinder 90 at its upper end, and it has a spool structure 170 at its lower end, formed with a circumferential channel 172. The rod and roller assembly 154, 156, which is mounted by the ears 153, is engaged within the channel 172 of the spool structure 170; axial movement of the center shaft 88 will thus effect oblique movement of the slide assembly 108 within the head slot 27.

Generally describing operation, the fully retracted position of the cutting head is shown in Figure 10, and is achieved by the application of pneumatic lifting pressure to one side of the piston within the cylinder 90. Upon release of that pressure the coil spring 98, acting upon the spur gear and the collar unit 92, will thrust the head assembly 26 downwardly and bring the glide plate 68 into contact with the surface S of the workpiece W. Pneumatic pressure that builds within the cylinder 90 on the opposite side of the piston will then force the center shaft 88 downwardly, in turn shifting the slide assembly 108 and causing the cutting tip of the blade 112 to project through the glide plate opening 174 and to plunge into the workpiece W. Translational movement of the Y gantry 22 on the top and bottom rails 14, 16, translational movement of the carrier 84 on the Y gantry, and rotation of the head assembly 26 by the stepper motor 96, will cause the blade 112 to cut the selected, programmed opening "O" in the workpiece W. Upon completion of the cutting operation the pneumatic pressure delivered to the cylinder 90 will be shifted to lift the cutting head assembly 26 away from the workpiece, against the force of the spring 98, awaiting a subsequent command from the terminal 34 and the computer 32.

Figure 21 shows the back side of the table 12, against which is mounted the pneumatic control unit, generally designated by the numeral 180, and the system of pneumatic conduits that connect the cylinders 46 of the clamping units thereto. A first line A connects in series the Tee connector 70 of each cylinder 46 of the vertical array, terminating at an elbow connector 176 on the end-most cylinder 46'. Pressure through line A will force all of the clamp buttons 54 of the vertically aligned clamping

units to their elevated, release positions. Line B is attached to the Tee connectors 72 of the same units, again ending in an elbow 178, and serves to deliver pressurized air to the opposite sides of the cylinder pistons so as to shift the buttons 54 to their downward, clamping positions. Similarly, line C is attached to the Tee connectors 70 of the horizontal array of cylinders 46 to impart lifting forces, ending at an elbow connector 176 of the end-most cylinder 46"; the line D terminates at elbow 178, and conducts pressure for closing of the horizontally aligned clamp units.

The pneumatic control unit 180 includes a main regulator 182 having a connector 183 for receiving line pressure; typically, the regulator 182 will deliver air at 50 psi pressure. The outlet 185 from the regulator 182 is joined to a Tee connector 187, one leg of which is connected to line 188 which leads to a Tee 189. One branch of the Tee 189 is connected to a regulator 184, typically set to deliver 30 psi pressure, from which extends a line 190 that is connected to a solenoid-operated valve 186. As is the case all other of the solenoid valves employed in the unit, suitable electrical connections to the computer and control cabinet 32 are established from a main electronic connector 191. With the valve 186 in the position depicted, pressure received through line 190 is directed through line 192 to the lines A and C, simultaneously applying lifting force to all of the clamp buttons 54. Shifting the valve 186 to its alternative position directs air pressure through line 194, connected to lines B and D, thereby forcing the clamp buttons 54 downwardly to their clamping positions.

A second line 196 from the Tee connector 188 leads to a second valve 198. One line 200 from the valve 198 conducts pressure to the fixture 91 on the head cylinder 90, thereby providing the means by which the head assembly 26 is moved to its elevated position. Shifting of the valve 198 to its alternate position will direct the air through the line 203 to the connector 93 on the head cylinder, thus applying downward force to the center shaft 88.

A second line 204 extends from the Tee connector 187 and leads to a regulator 205, from which a line 206 connects to a third solenoid valve 207, typically regulated to supply a pressure of about 32 psi. Line 208 connects the valve 207 to the valve 198. When the valve 207 is in its open position, and the valve 198 is shifted to apply downward force to the center shaft, air is delivered through line 208 to the opposite side of the piston in the cylinder 90 so as to apply elevating force through line 200, thus counteracting the downward force applied through line 203. This feature is employed primarily when the cutter is used for making circular or oval cuts in the workpiece, and serves to decrease the rate at which a blade is plunged. By applying the counteracting force for approximately 20° of movement of the head and by overcutting that 20° arc at the end of the stroke, with the full pressure applied (i.e., the counteracting pressure having been removed), nicks and fugitive cuts are avoided to produce a clean and well-defined opening in the workpiece.

Thus, it can be seen that the present invention provides a novel cutting head assembly suitable for use in a matcutter, and especially a computerized automated matcutter, wherein operation of the head components is smooth and well controlled and the parts are constructed for facile and precise relative positioning and repositioning.